XLI.—*The Life-history and Growth-rate of the Lesser Sand-Eel* (Ammodytes tobianus). By ARTHUR T. MASTERMAN, B.A. (Cantab.), Assistant Professor of Zoology, St. Andrews University.

SINCE I have had my attention turned to the subject of the growth of fishes Professor M'Intosh has kindly handed over to me for examination a unique and very complete collection of the lesser sand-eel. Almost every size and stage is represented, from the embryo to the adult, and in many cases in such abundance as to give valuable data upon the subject at hand. In the 'Twelfth Annual Scottish Fishery Board Report' there appeared a table which purported to set forth the sizes of this collection, and I had hoped to avail myself of this; but an inspection led one to detect so many inaccuracies and wide approximations that the table is practically useless as a record of facts *. I have therefore gone through the whole collection except one bottle (labelled April 18, 1891), which was kindly worked through by my friend Mr. H. C. Williamson, M.A., B.Sc., a certain proportion being measured and the rest counted.

Without inquiring in too much detail into any reasons for the inaccuracy of Fullarton's table, we must mention that the sizes given by him amongst the March bottom-net series,

* 'On the Oviposition and Growth of the Lesser Sand-Eel,' by J. H. Fullarton. We may give one instance from this paper to show to what kind of work our remarks refer (p. 317). The same specimens are entered twice :—

Date of capture.	No. of Specimens.	Length in millims.
May 1	1	10
	6	9
	33	8
	53	7
	39	6
	13	5
	4	4
May 4	1	10
	6	9
	33	8
	53	7
	39	6
	13	5
	4	4

which are so largely in excess of mine in length, are accounted for by the fact that there were included in the bottles a number of larval herrings, which he appears to have measured and added to his list of sand-eels ; and these, although recently hatched, are much longer than the older sand-eels occurring with them. Apart from the more attenuated form, the presence in some of the yolk-sac, the difference in pigmentation and in the position of the arms, are points which at once distinguish the two forms.

In my last paper upon the plaice * I dealt with a fish whose spawning-period is accurately known within fairly narrow limits, and therefore the base-line or starting-point of any growth-curve is also known. In this case, on the contrary, there is a good deal of doubt concerning the spawning-period, and it is hoped with this series to form a growth-curve which may help to the determination of this difficult point. At the risk of redundancy it is well to recapitulate the views held by various observers.

Couch † describes in accurate and detailed language the spawning process of the sand-eel, and as the result of his observations gives the shortest days of the year as the spawning-period on the south coast.

Thompson corroborates this observation, but also gives July as the spawning month in Ireland. Day ‡ finds the ovaries advanced in August and September, and M'Intosh § finds the same condition in May and June. Fulton § states that ripe specimens are caught in the end of June at Dunbar. Fullarton ‖ describes having met with spawning females in July.

These divergent opinions by various observers can only be reconciled in one way, namely, by assuming that the lesser sand-eel has two spawning-periods, more or less confluent. It will be seen that the summer spawning-habit is proved by the observations of Thompson, M'Intosh, Fulton, and Fullarton ; whilst the winter is proved by Couch and Thompson, and possibly by Day. The herring, whose larval form resembles the sand-eel closely in habits and *general* features, is known to have two spawning-periods, and we shall see below that on no other assumption can the facts with which we have to deal be explained. In Table I. are placed all the

* "On Rate of Growth of the Plaice," Thirteenth Annual Scott. Fishery Board Report.
† 'Fishes of the British Islands,' vol. iii.
‡ 'British Fishes,' vol. i.
§ 'Ninth Scott. Fishery Board Report.'
‖ 'Twelfth Scott. Fishery Board Report.

measured specimens, grouped according to the months ; and, without going further, it is evident that there is a series of larval sand-eels found in March and April, and another series, in lesser numbers, in the end of July and August. The enormous quantities of larvæ which suddenly make their appearance in March at the sandy bottom some way from shore show a gradation in size, the smallest being 3·8 to 4 millim. (in spirit) ; and, by the presence of an oil-globule and traces of yolk, they must have just reached the end of the larval period. The period of hatching is in the summer about ten days, so that a period of incubation of three weeks would not be excessive for the mid-winter time (see my remarks on plaice). The larval period will also be considerably prolonged. For the summer larvæ a more or less quiescent larval period of two weeks would not be abnormal from the analogy of other species, and this is probably understating the case. This will give us a larval period of four weeks in the winter at least, and therefore we may say that the larvæ found in early March were probably spawned at the end of the year (incubation three weeks, larval period four or five weeks). This date would agree with the observations of Couch, quoted above, on the date of spawning. We know that the sand-eel lays its eggs *in* the sand, and it would not be a great assumption to suppose that the newly-hatched larvæ avail themselves of the protection afforded by their surroundings to remain in the sand until, the yolk being nearly absorbed, they emerge from their concealment and suddenly appear in countless numbers upon the sandy bottom. There are facts to hand which point to the conclusion that some young littoral pleuronectids (plaice &c.) take refuge during the winter months by embedding themselves in the sand. (On this point see also Petersen, ' Report Danish Biol. Stat.,' 1893.)

Although there is a certain amount of hypothesis in this account, yet it must be said that it agrees exactly with the facts at present known, and no other theory has yet fulfilled these conditions. Fullarton has put forward the suggestion that the little March larvæ are from the previous summer's spawning :—" Those captured in March, April, and May . . . . may be considered as having been hatched towards the latter part of the previous spawning-period." This assumption would require that these little larvæ with oil-globules and, in some cases, traces of yolk, many not exceeding in size the just-hatched summer forms, must be at least seven months old, the first three of which are the hottest and best growing months of the year. This difficulty is got over by assuming that the spawning-period extends from " June till

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